Status of the NPDGamma Experiment

Lujan Center Flight Path 12

Greg Mitchell
P-23

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LANSCE Group Leader Council Meeting

NPDGamma is a nuclear physics experiment which requires a pulsed cold neutron beamline.

LANSCE

is the only facility worldwide which can host NPDGamma.

NPDGamma is under construction and will begin data collection in 2003.

Measurement of the Parity-Violating Gamma Asymmetry A_γ in the Capture of Polarized Cold Neutrons by Para-Hydrogen, $\vec{n} + p \rightarrow d + \gamma$

J.D. Bowman (Spokesperson), G.L. Greene, G.E. Hogan, J.N. Knudson, S.K. Lamoreaux, G.S. Mitchell, G.L. Morgan, C.L. Morris, S.I. Penttilä, D.A. Smith, T.B. Smith, W.S. Wilburn, and V.W. Yuan
Los Alamos National Laboratory

C.S. Blessinger, M. Gericke, G. Hansen, H. Nann, and W.M. Snow
Indiana University

T.E. Chupp, K.P. Coulter, R.C. Welsh, and J. Zerger
University of Michigan

M.S. Dewey, T.R. Gentile, D.R. Rich, and F.E. Wietfeldt
National Institute of Standards and Technology

T.A. Case, S.J. Freedman, and B.K. Fujikawa
University of California, Berkeley

R.D. Carlini
Thomas Jefferson National Accelerator Facility

S. Ishimoto, Y. Masuda, and K. Morimoto
KEK National Laboratory, Japan

G.L. Jones
Hamilton College

F.W. Hersman, M.B. Leuschner, and V.R. Pomeroy
University of New Hampshire

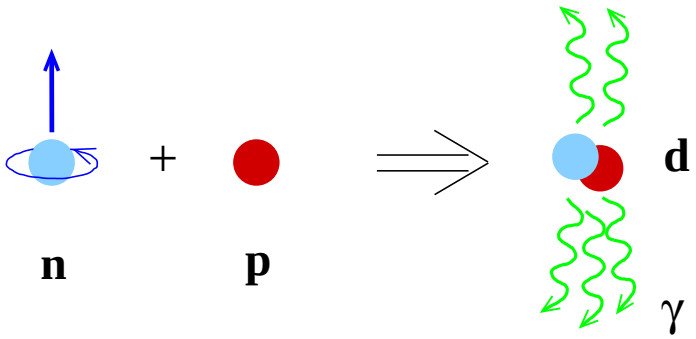
S.A. Page and W.D. Ramsay
University of Manitoba and TRIUMF

E.I. Sharapov
Joint Institute for Nuclear Research, Dubna

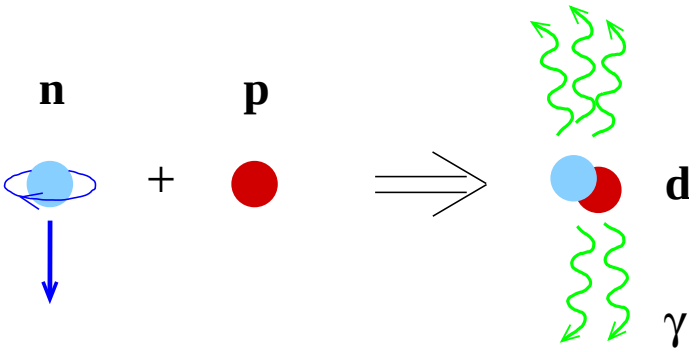
http://p23.lanl.gov/len/npdg/

$\vec{n} + p \rightarrow d + \gamma$ (2.2 MeV)

NPDGamma will measure A_γ, the parity-violating asymmetry in the distribution of emitted γ's



flip neutron spin



If the γ rates differ for the two cases, i.e. more γ's emitted up than down, then parity is violated (PV $\longrightarrow$ signature of the weak interaction)

Expected asymmetry $\approx 5 \times 10^{-8}$

Goal experimental error: 0.5×10^{-8}

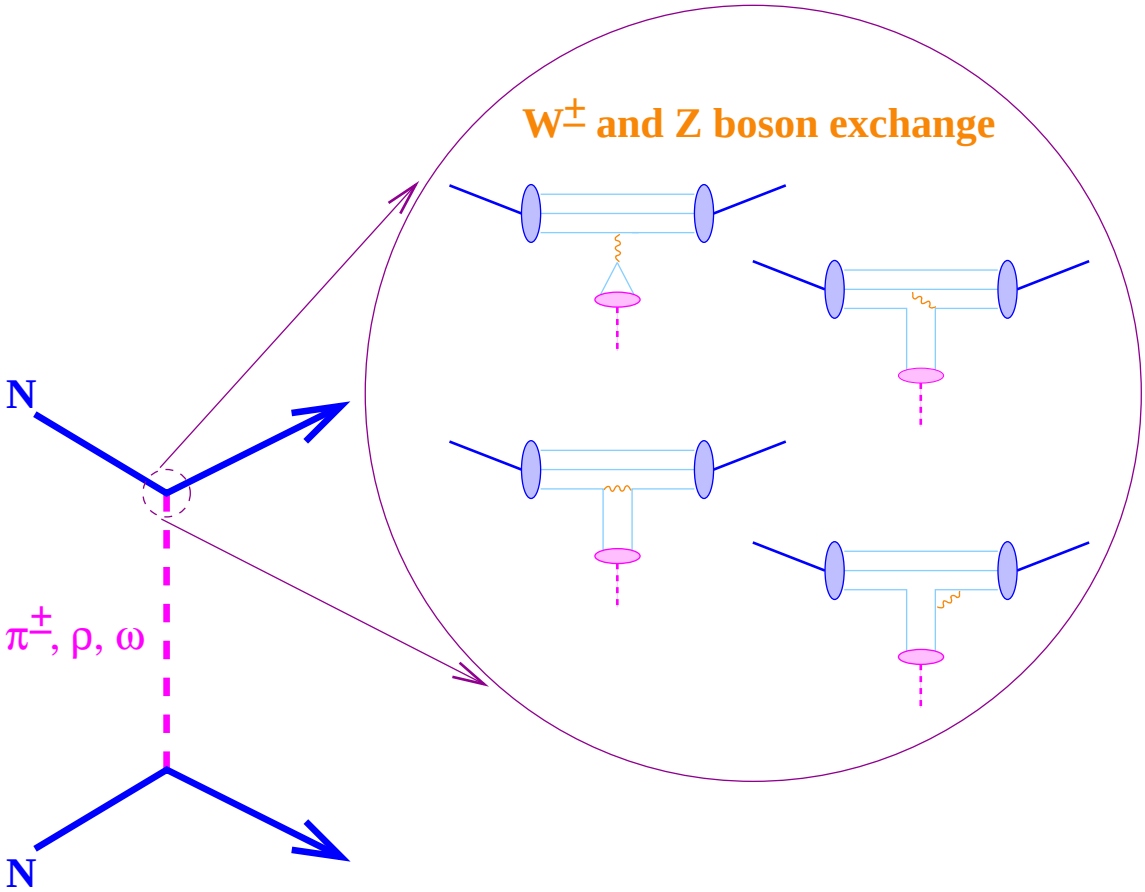
Range of Z, W^+, W^- bosons is 0.002 fm

But nucleon interactions take place
on a scale of 1 fm (short range repulsion)

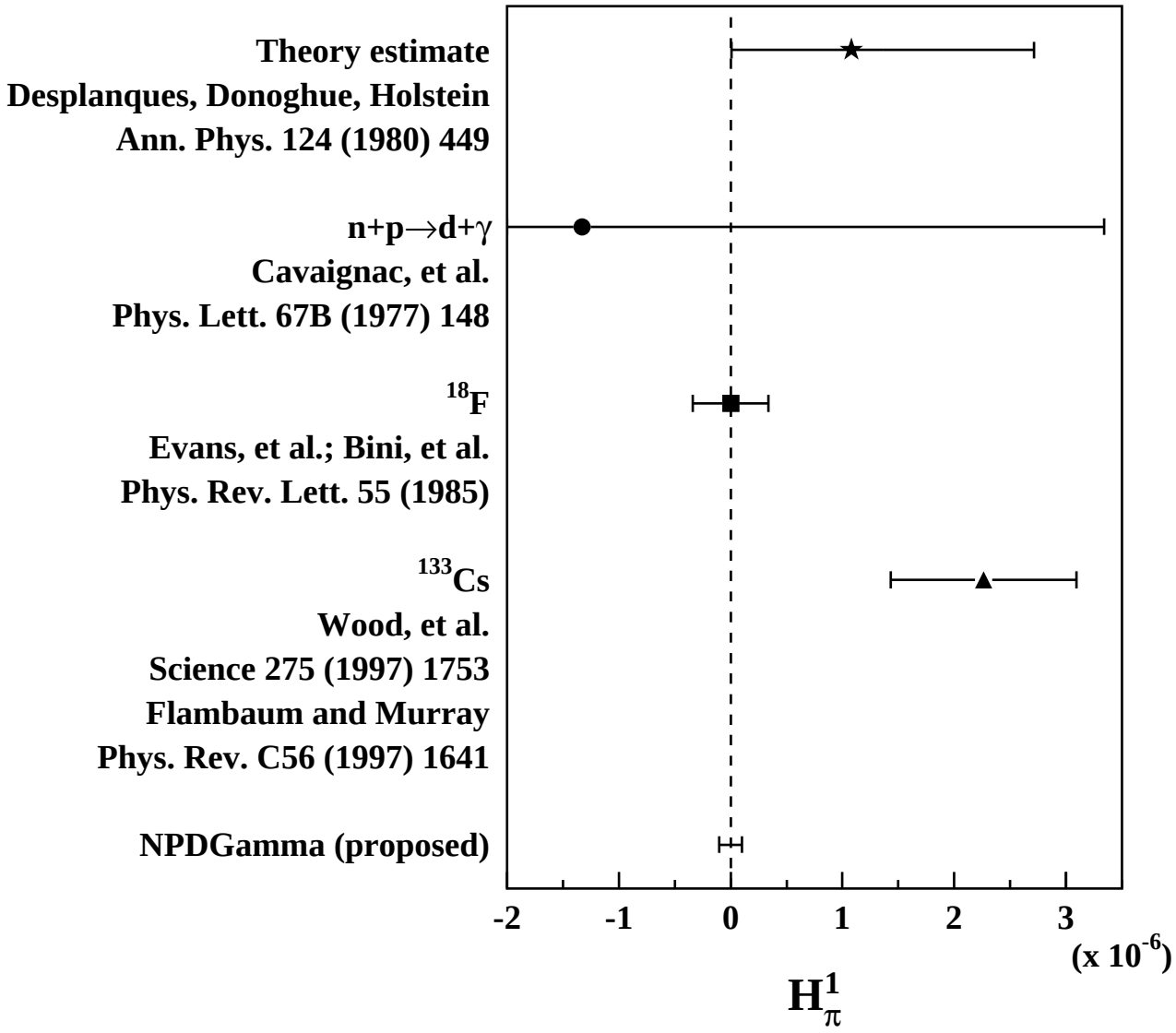
model the weak force interaction between nucleons and hadrons as meson exchange

At low energies (< 300 MeV)
mesons are the appropriate degree of freedom

Meson exchange model is a successful picture of strong interactions between nucleons (describes to a few % n-p/p-p scattering cross-sections)

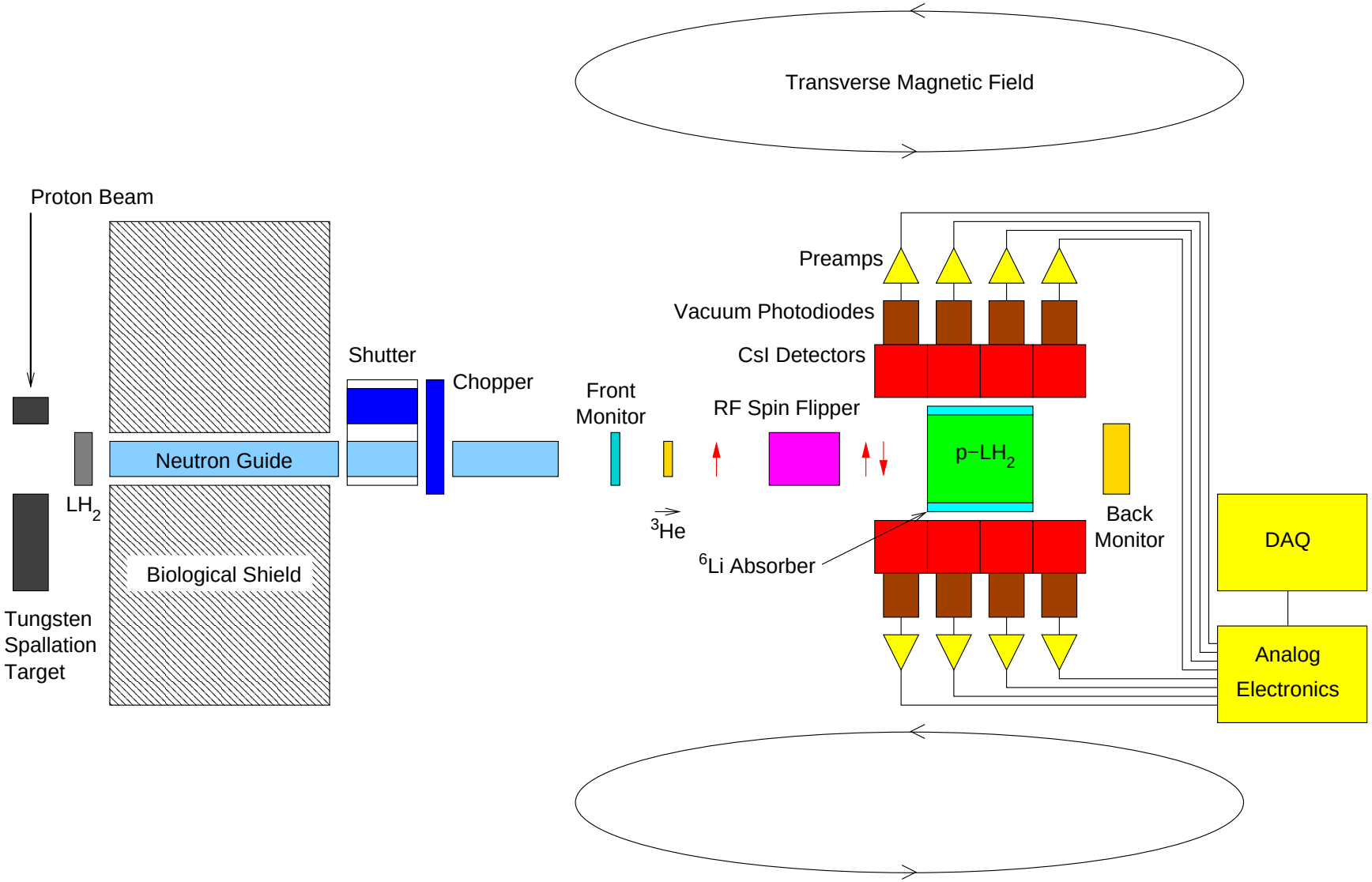


A_γ is a clean measurement of H_π^1: $A_\gamma \approx -0.045 H_\pi^1$



NPDGamma will provide a measurement with improved statistical precision compared to ^{18}F results, with no uncertainties from many-body calculations or nuclear structure effects

NPDGamma Experimental Setup



NPDGamma is a funded experiment ($4.8M)

DOE & NSF

also Hamilton College, Indiana University, KEK, University of Manitoba, University of Michigan, NIST, University of New Hampshire, TJNAF

NPDGamma Vital Statistics

neutron beam polarized by ^{3}He spin filter
neutron polarization: 0.50 $\rightarrow$ 0.95

FP12 peak flux: 6×10^7 n/ms (@ 8 meV = 3.2 Å)

event rate per 20 Hz pulse: 8×10^7

γ's from neutron capture detected by CsI(Tl) and photodiode detector array operating in current mode

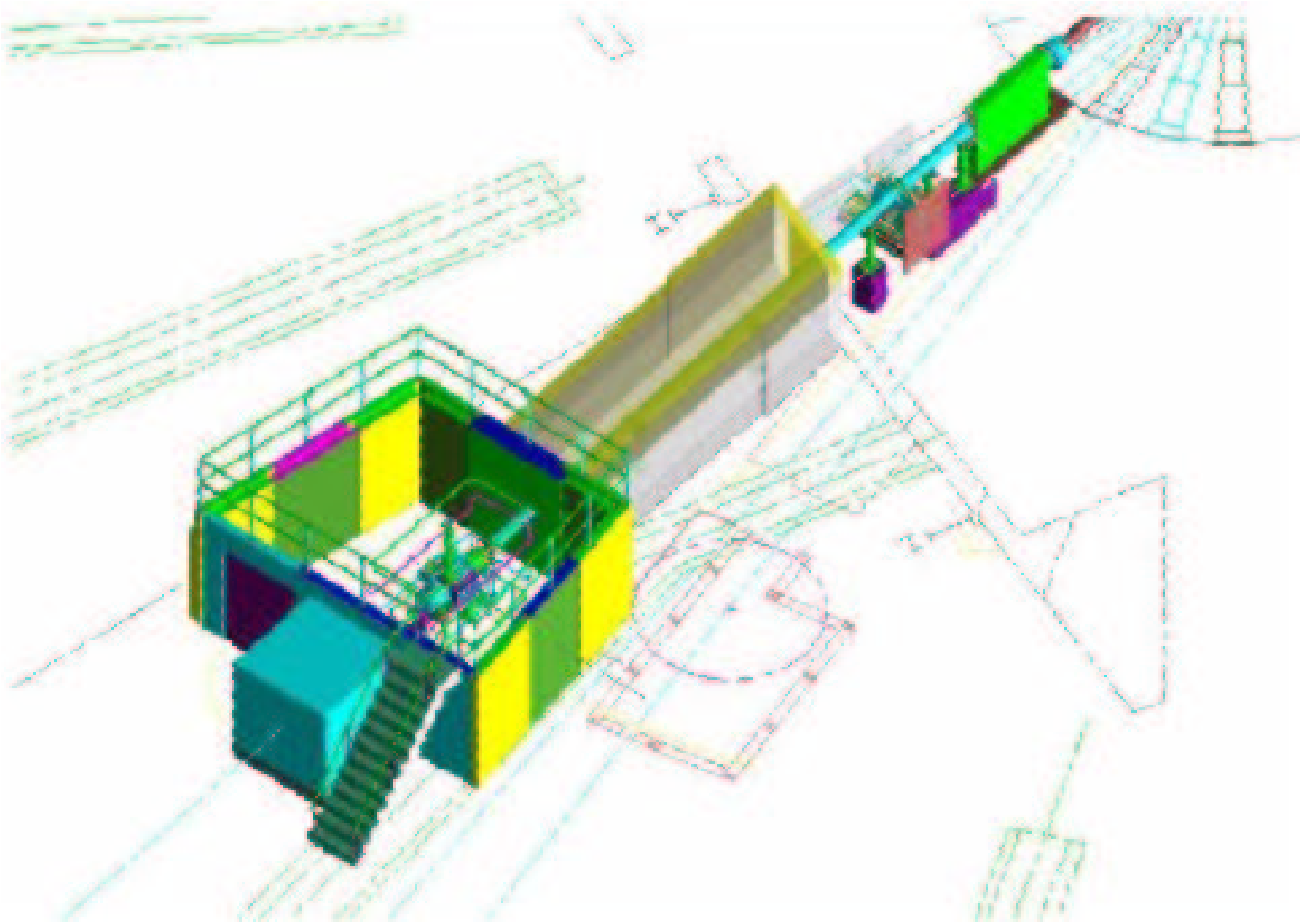
gain provided by low-noise solid-state preamplifiers

run time: 3 $\times$ 2500 hours delivered, w/150 μA

NPDGamma is building FP12 to be ready for:

commissioning run Summer 2003

production data taking Fall 2003

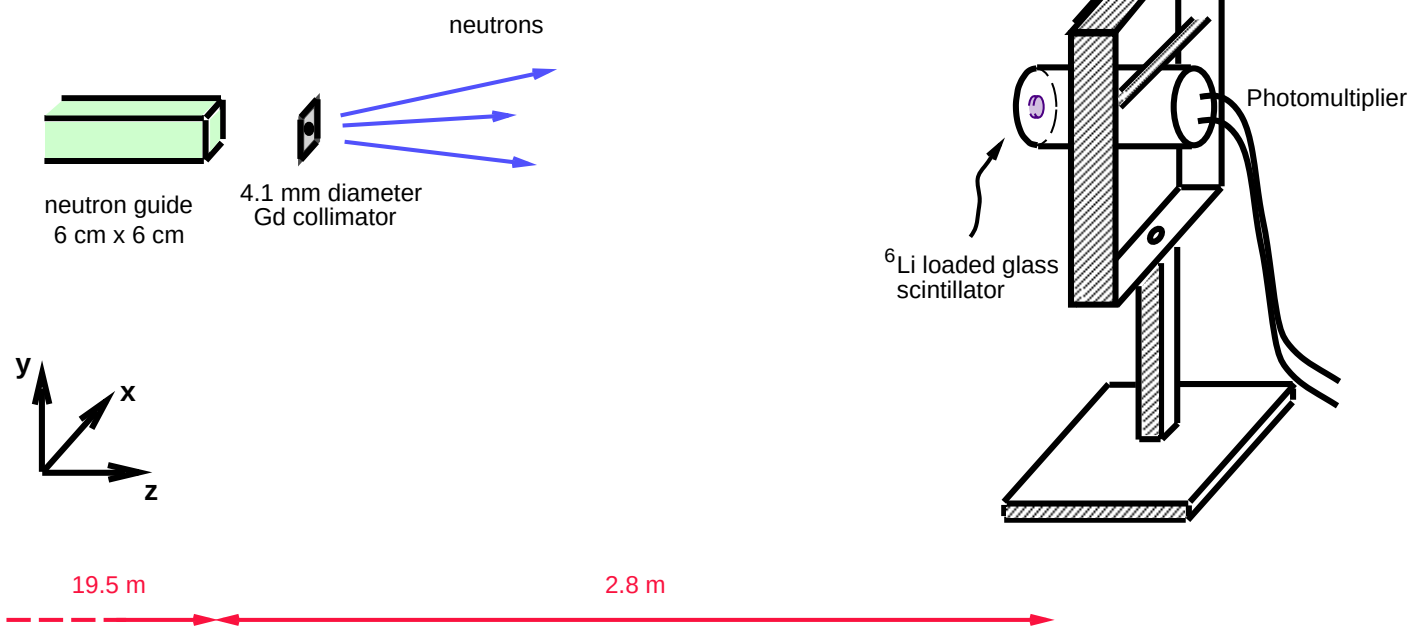


(MOU between LANSCE and P Divisions)

Neutron Flux Measurement (FP11A, Fall 2000)

Measured the flux by collimating the beam and counting with a small detector on a movable stage

Necessary to validate run time estimates

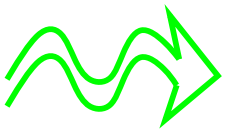


$$n + {}^6Li \rightarrow {}^4He + {}^3H + 4.78\ MeV$$

$$\sigma(b) = 149/\sqrt{E(eV)}$$

Neutron Flux Measurement (FP11A, Fall 2000)

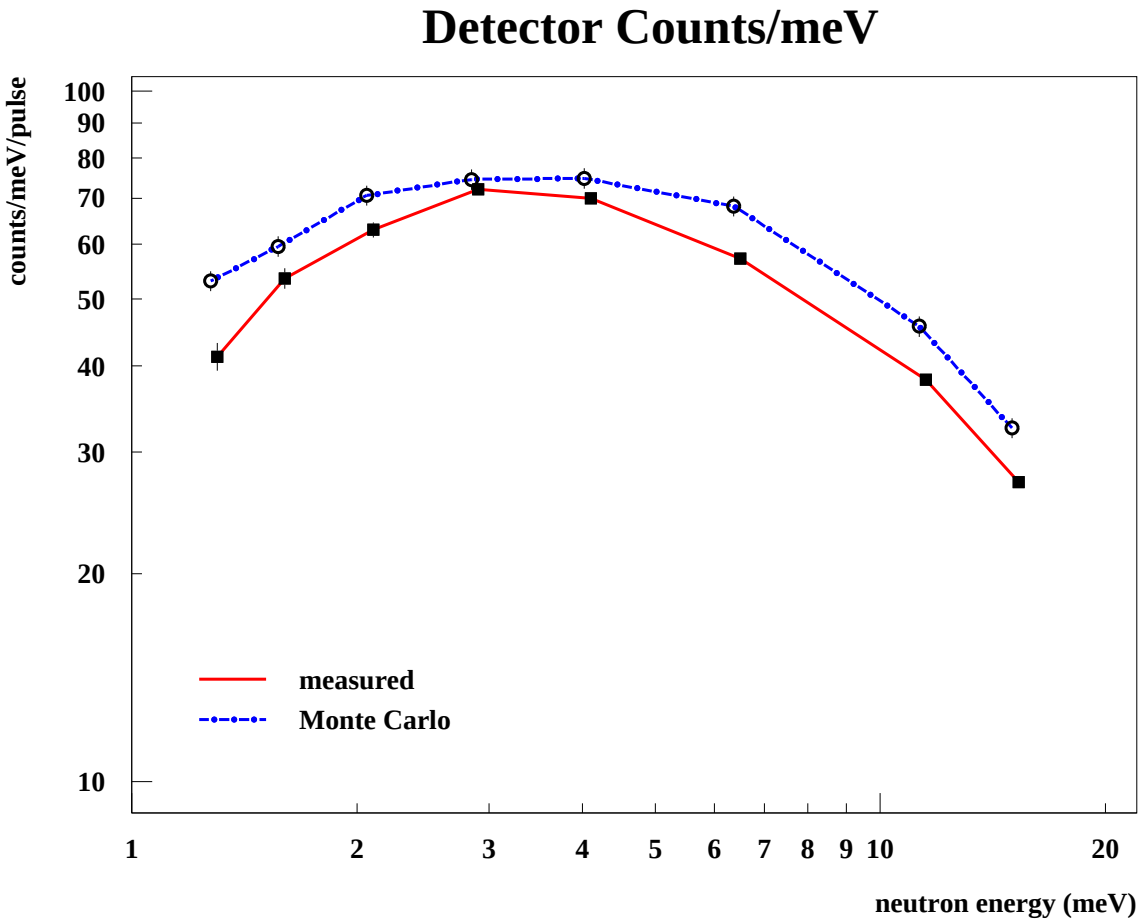
Compare measured flux to predicted flux for a partially coupled LH_2 moderator, using a Monte Carlo to calculate neutron guide transport and collimation effects for FP11A



Excellent agreement (20%)
with magnitude and E dependence

FP12 flux will be sufficient for NPDGamma and have a demonstrated method to measure it

($\sigma_{\text{stat}} = 0.5 \times 10^{-8}$ in three 2500 hr run cycles, w/150 μA)



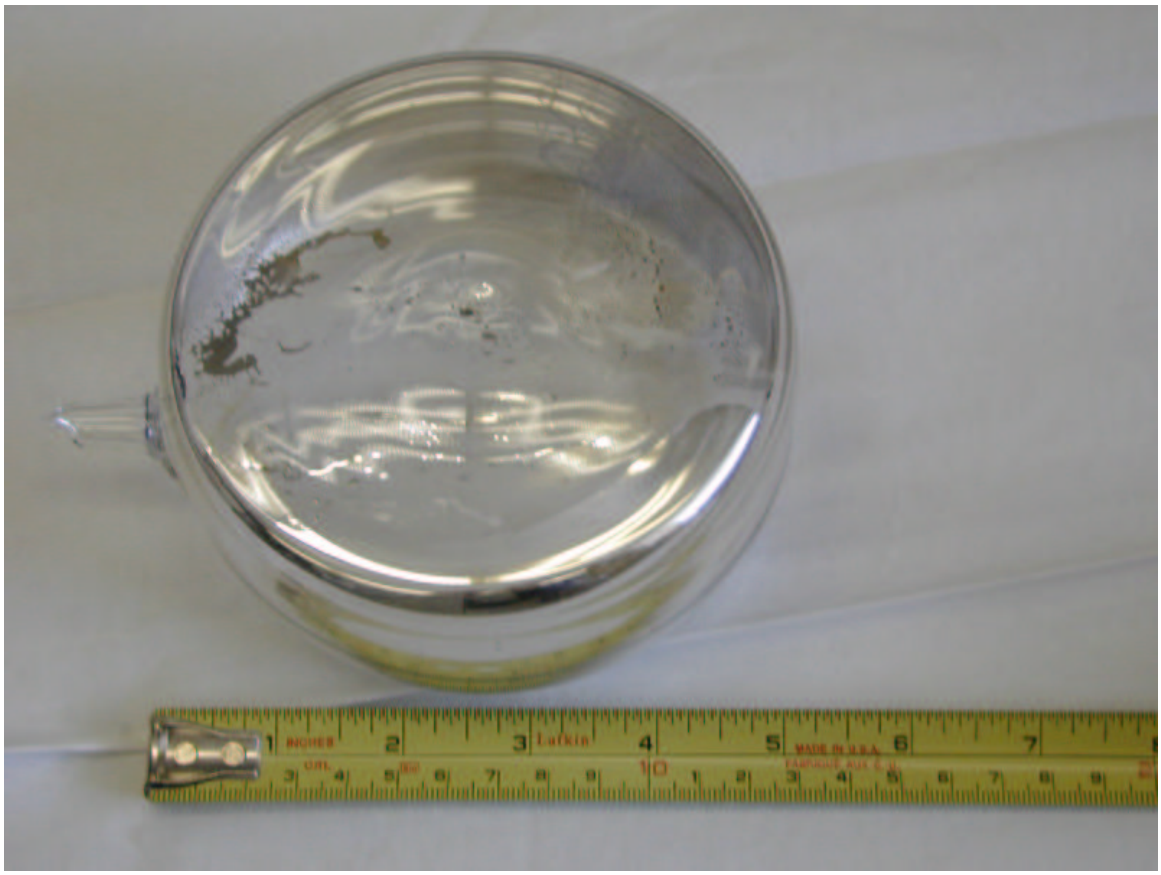
(Data from Fall 2000 on FP11A, 100 μA)

^{3}He Spin Filter

Optical pumping of Rb vapor, which polarizes ^{3}He by hyperfine spin-exchange collisions.

Neutron beam is polarized by passing through the cell. Antiparallel spin neutrons absorbed.

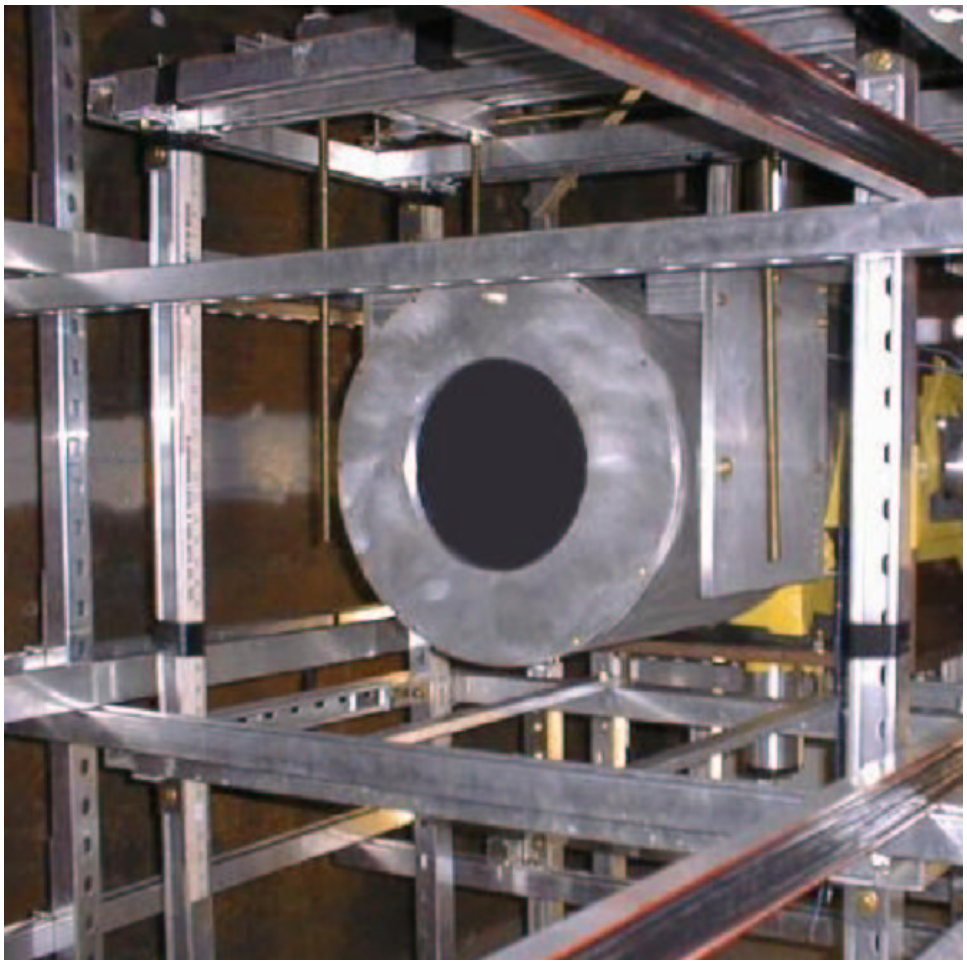
Fall 2000 Test Run: ^{3}He polarization of 26.5% $\longrightarrow$ n polarization of 30-70% for 2-10 meV

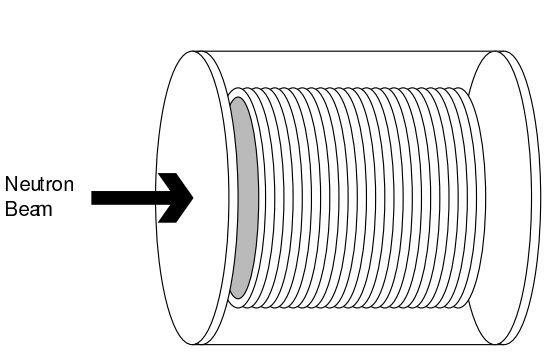


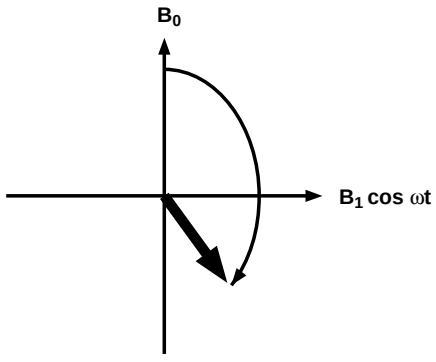
NIST group has fabricated large single cell: 12 cm dia., $T_1 > 500$ hr $\rightarrow$ 50% ^{3}He pol.

Radio Frequency Spin Flipper

In a DC magnetic field, apply a resonant RF magnetic field to precess the neutron spin by π



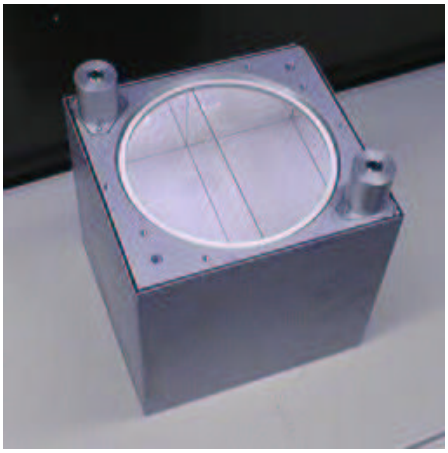


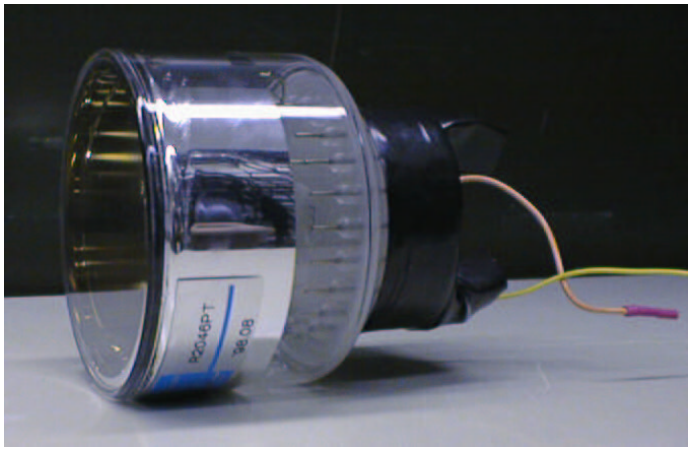


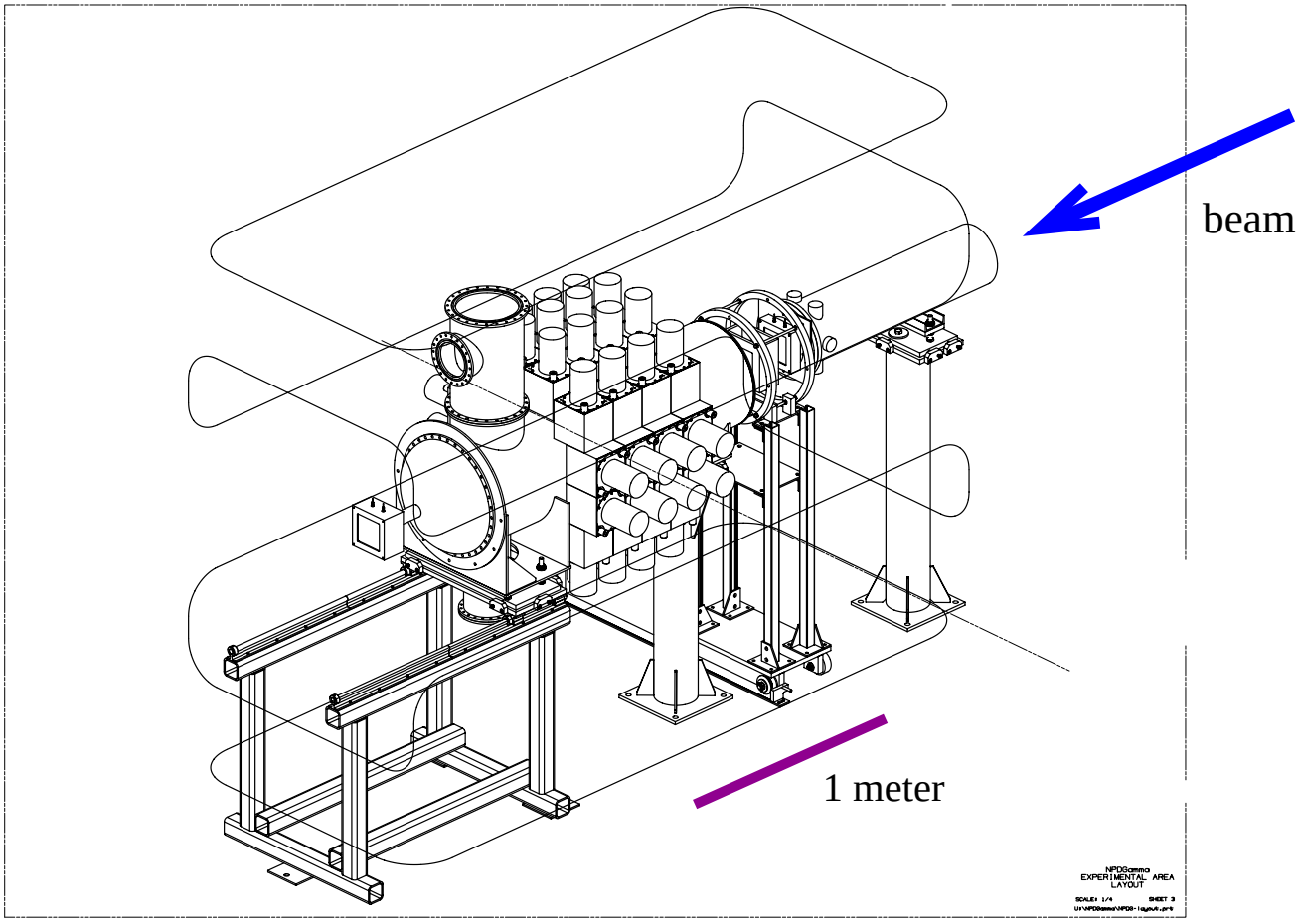
Spin flipper efficiency:
measured >95% on axis in Fall 2000

CsI(Tl) and Photodiode γ Detectors

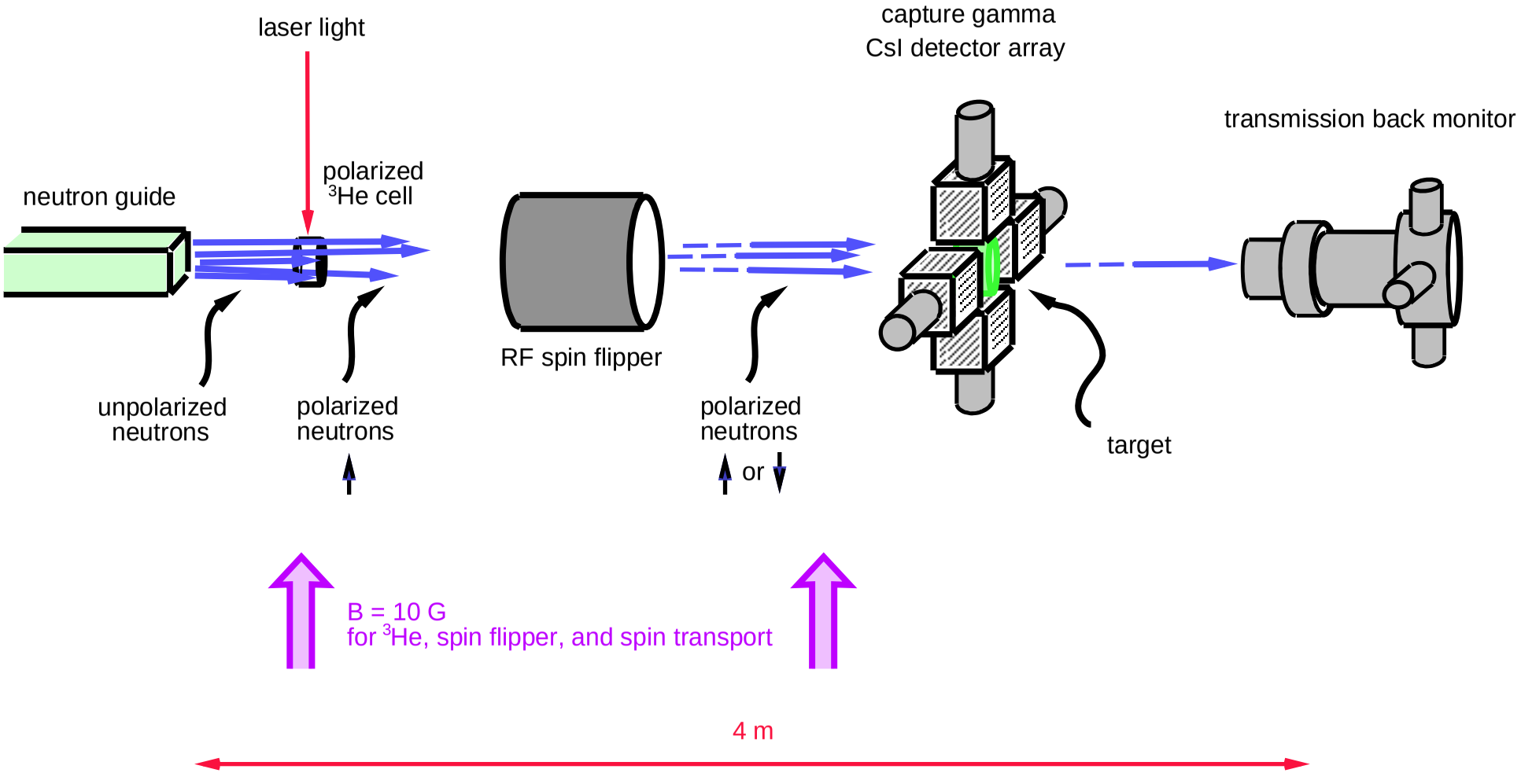
48 of these detectors will be used in the full experiment





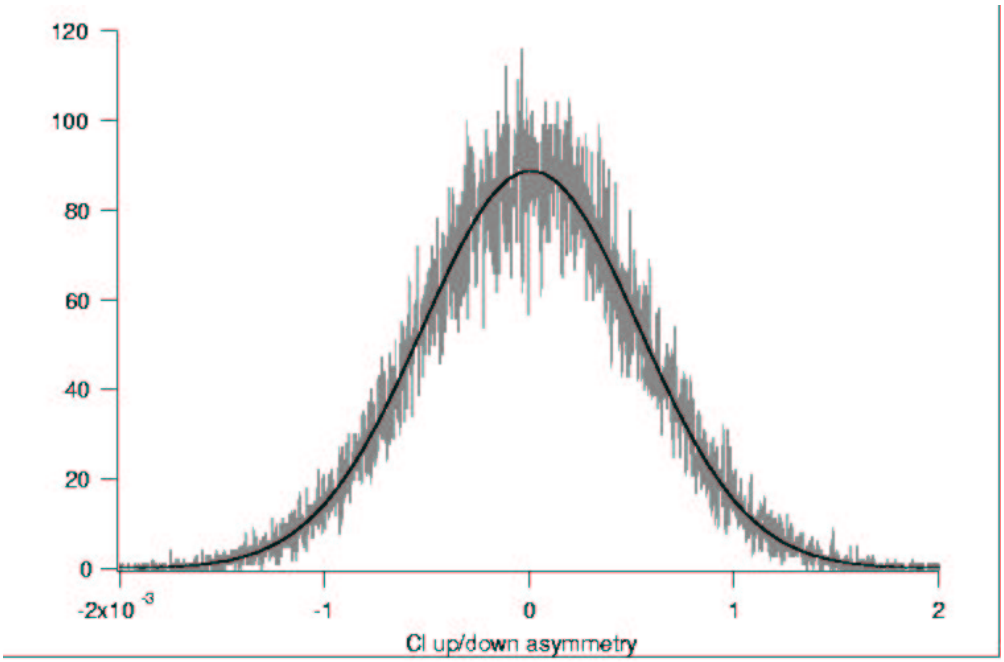


Fall 2000 Engineering Run Setup



Asymmetry measurements on Cl, La, Cd

up/down $\rightarrow$ parity violating



Raw PV Asymmetries ($\times 10^{-6}$)

^{35}Cl	-7.68 ± 2.17
^{139}La	-5.88 ± 2.35
^{113}Cd	$+1.94 \pm 1.48$

Physics Asymmetries A_γ ($\times 10^{-6}$)

	^{35}Cl	^{113}Cd	^{139}La
Leningrad	-27.8 ± 4.9	-1.3 ± 1.4	-17.8 ± 2.2
ILL	-21.2 ± 1.7	-	-
LANSCE	-23.1 ± 6.5	$+5.8 \pm 4.4$	-17.1 ± 6.8

(LANSCE results to be published.)

NPDGamma Status

- FP12 flight path is under construction.

- Experiment is under construction.
  10% scale apparatus tested Fall 2000.
  Alignment scheme & monitors tested Fall 2001.
  All crucial components demonstrated.

- Test runs indicate design is sufficient for target A_γ experimental error, 0.5×10^{-8}.

- NPDGamma will make a clean measurement of H^1_π, the most fundamental weak N-N coupling.

NPDGamma Schedule

January 2002	Start beamline installation
January 2003	Installation of guide complete
June 2003	FP12 Commissioning Run
August 2003	Commission entire experiment
Fall 2003	Begin data taking
December 2003	Data match existing stat. precision on H^1_π